



TDWR RDA Upgrade Status

**John Cho
Nathan Parker**

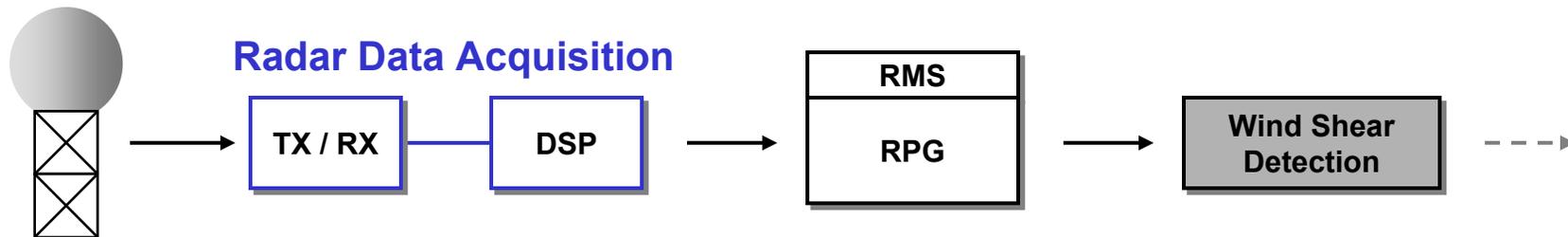
28 March 2007

FAA ATO-T Program

MIT Lincoln Laboratory



Upgrades to the TDWR Processing Chain



1. **Rehost RMS/RPG computer (FAA deployed)**
 - Port from Harris to SGI computer
2. **Rehost Outboard MIGFA (FAA demonstrated at OKC)**
 - Move outboard MIGFA to RMS/RPG computer
3. **Retrofit RDA (Lincoln/FAA will demo at SLC in 2007)**
 - Build 1: Replace all hardware with new COTS system
 - Build 2: Upgrade software for RV ambiguity mitigation
 - Possible Build 3: Upgrade software for dry-site improvement
 - RPG software is modified for both Build 2 and Build 3



Production-like Prototype RDA

December 2005 at PSF in OKC

Down Converter

Lincoln-designed

Contract awarded to ARC



IF Digitizer

SIGMET RVP8™



Gigabit Ethernet switch



I/Q Data Recorder

with 1.7 TB disk array



Quad-Xeon DSP

Dell 6650 with

SIGMET RVP8™ Rx/Tx cards



Up Converter

Original to TDWR

MIT Lincoln Laboratory



Two 2-channel Prototypes in Operation

- **PSF (Oklahoma City, OK):**
 - Two channels installed Nov 2005
 - Runs when radar is not needed by PSF for field support



- **OEX (Oklahoma City, OK):**
 - Two channels installed Jan 2006
 - Runs when classes are not in session



Prototype hardware design has been stable since Nov 2005



Developing Two Versions of Software

- **“Build 1” – Legacy emulation**
 - Duplicates baseline functionality on a modern hardware/software platform
 - Little added functionality

- **“Build 2” – Mitigates RV ambiguity problem**
 - Enhanced ground clutter suppression
 - Uses adaptive transmission and signal processing



Build 1 Software Status

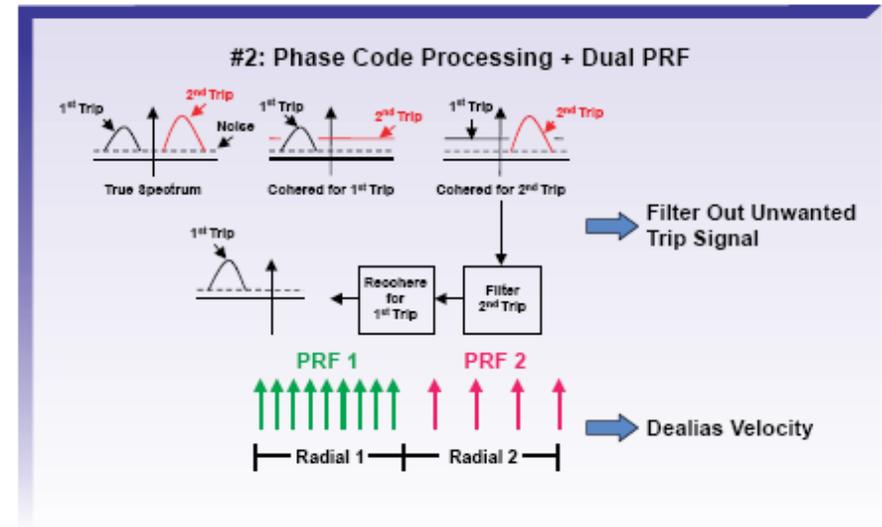
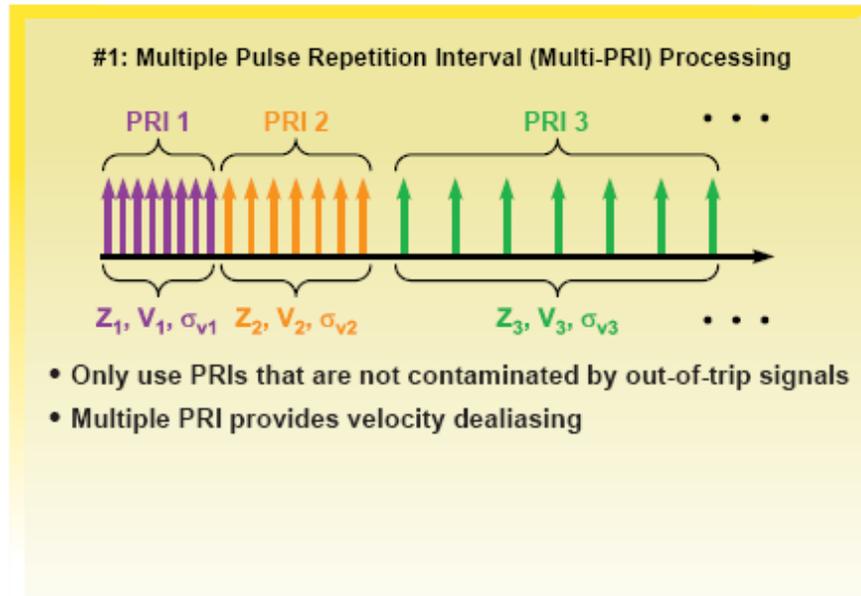
- **Software has been running bug-free for all of 2006**
- **Meteorological evaluation in Spring 2006 was successful**
- **AJW-144 tested against original TDWR acceptance procedures**
- **AJW-144 is satisfied with its operation**

Build 1 is complete



Build 2: RV Ambiguity Mitigation

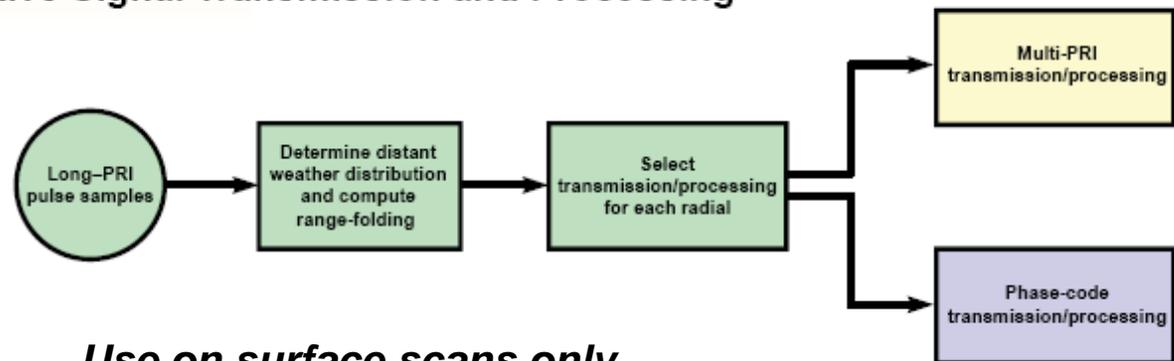
Range-Velocity Ambiguity Mitigation Techniques



Adaptive Signal Transmission and Processing

1st Trip Protection Comparison Chart

Technique \ Out-of-trip Signal Type	High Power or Wide Spectrum	Long Continuous Range Extent
Multi-PRI Processing	Yes	No
Phase-Code Processing	No	Yes

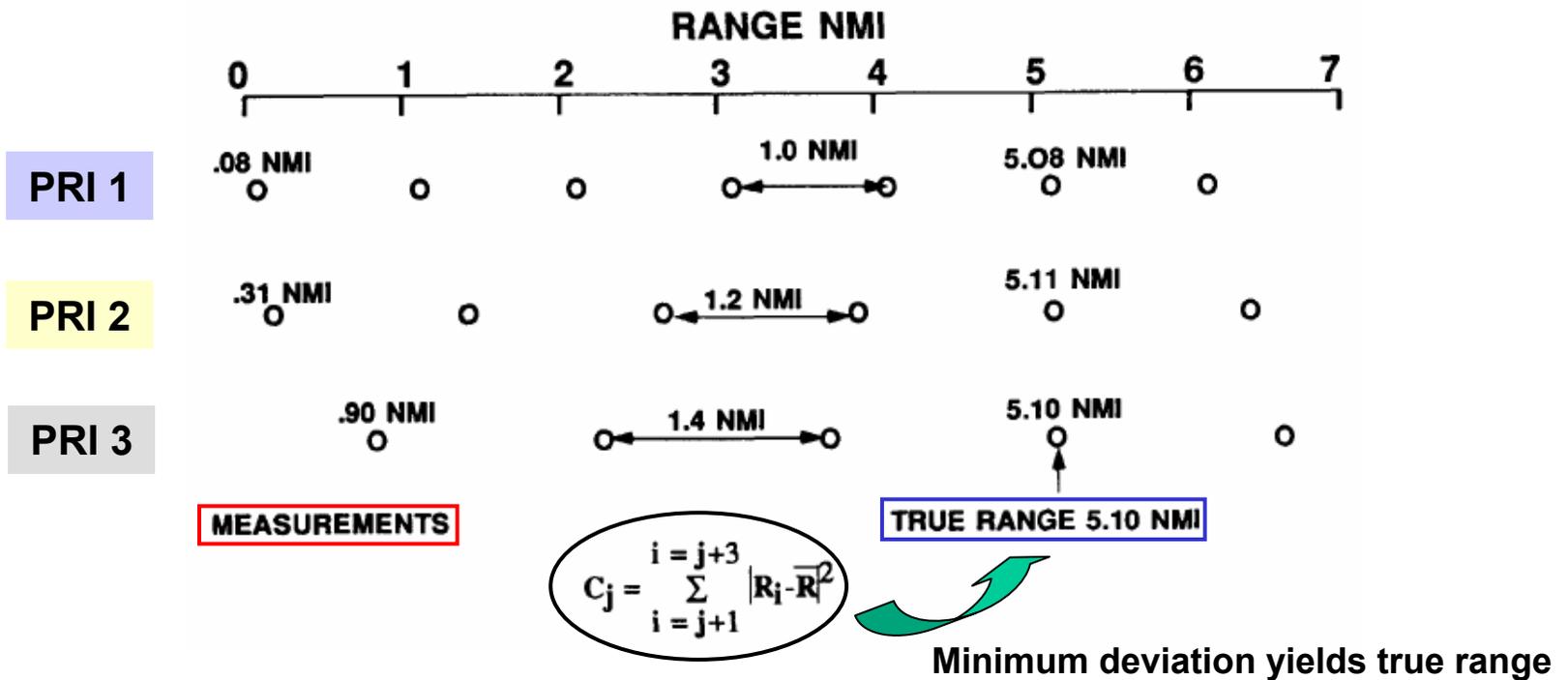


Use on surface scans only



Velocity Dealiasing

- Apply unfolded range clustering technique



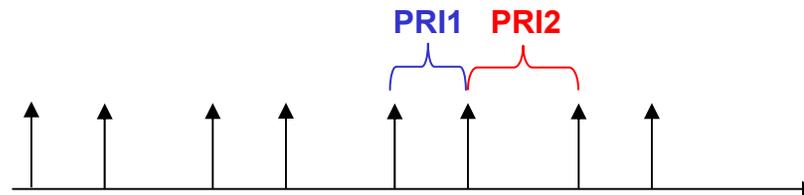


Mode vs. Elevation Angle

Elevation	Mode	RV Ambiguity
Surface	Low PRF, Adaptive*	RV
Surface < EL < 12°	Alternating-dwell dual-PRF with phase code	RV
EL ≥ 12°	Staggered PRI	V

*Multi-PRI and alternating-dwell dual-PRF with phase code

- **Low-PRF & adaptive mode requires 2 rotations per tilt**
 - Only used on 1 tilt ⇒ Saves 1 rotation compared to legacy volume scans
- **Staggered PRI yields best dealiased velocity estimates if range overlay not a problem ⇒ Use on upper tilts**



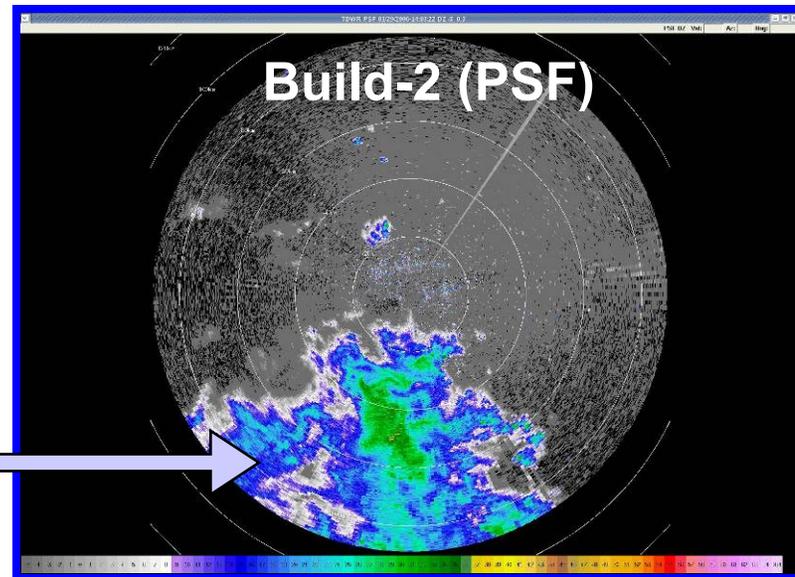
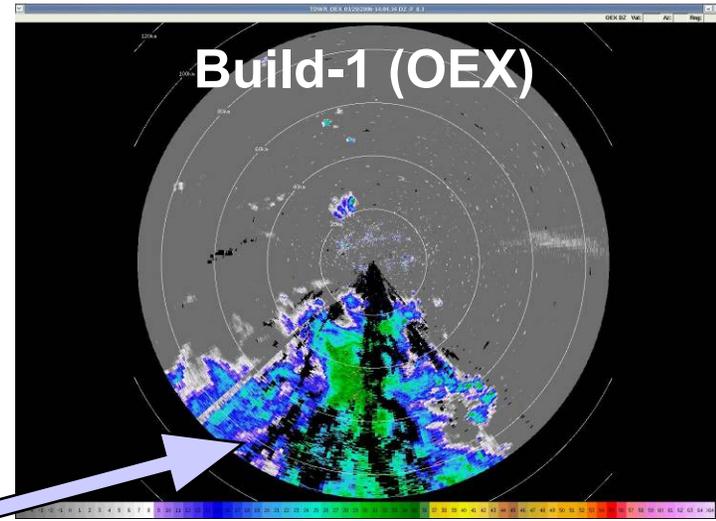
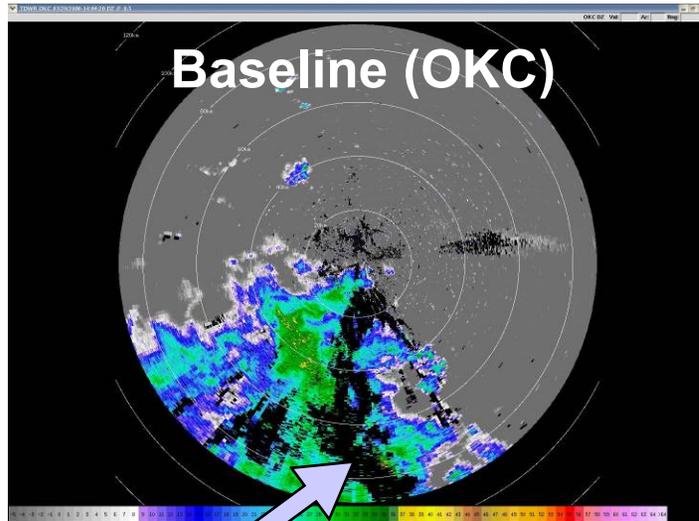


Clutter Filtering

- **Alternating-dwell dual-PRF with phase code**
 - Modified Gaussian model adaptive processing (GMAP)
 - Clutter filter interferes with 1st trip protection: Conditionals used to keep filter from being used unnecessarily
 - Clutter residue map (CREM) used for censoring at low elevations
- **Multi-PRI**
 - Modified GMAP on low-PRF scan yields clutter power estimates, which are used to select from 5 FIR filter levels
 - Conditionals used to keep filter from being used unnecessarily
 - CREM used for censoring
- **Staggered PRI**
 - Spectral deconvolution clutter filter [Sachidananda & Zrnić, 2002]
 - Conditionals used to keep filter from being used unnecessarily
- **With new RDA, 65 dB clutter suppression achieved on point-scanned stationary target (legacy stability limit = 60.7 dB)**



Build 2 Reduces Range Obscuration



Legacy algorithm censors regions with range-folded weather (black)

New algorithm recovers first-trip weather

2006-03-29 14:04 UTC

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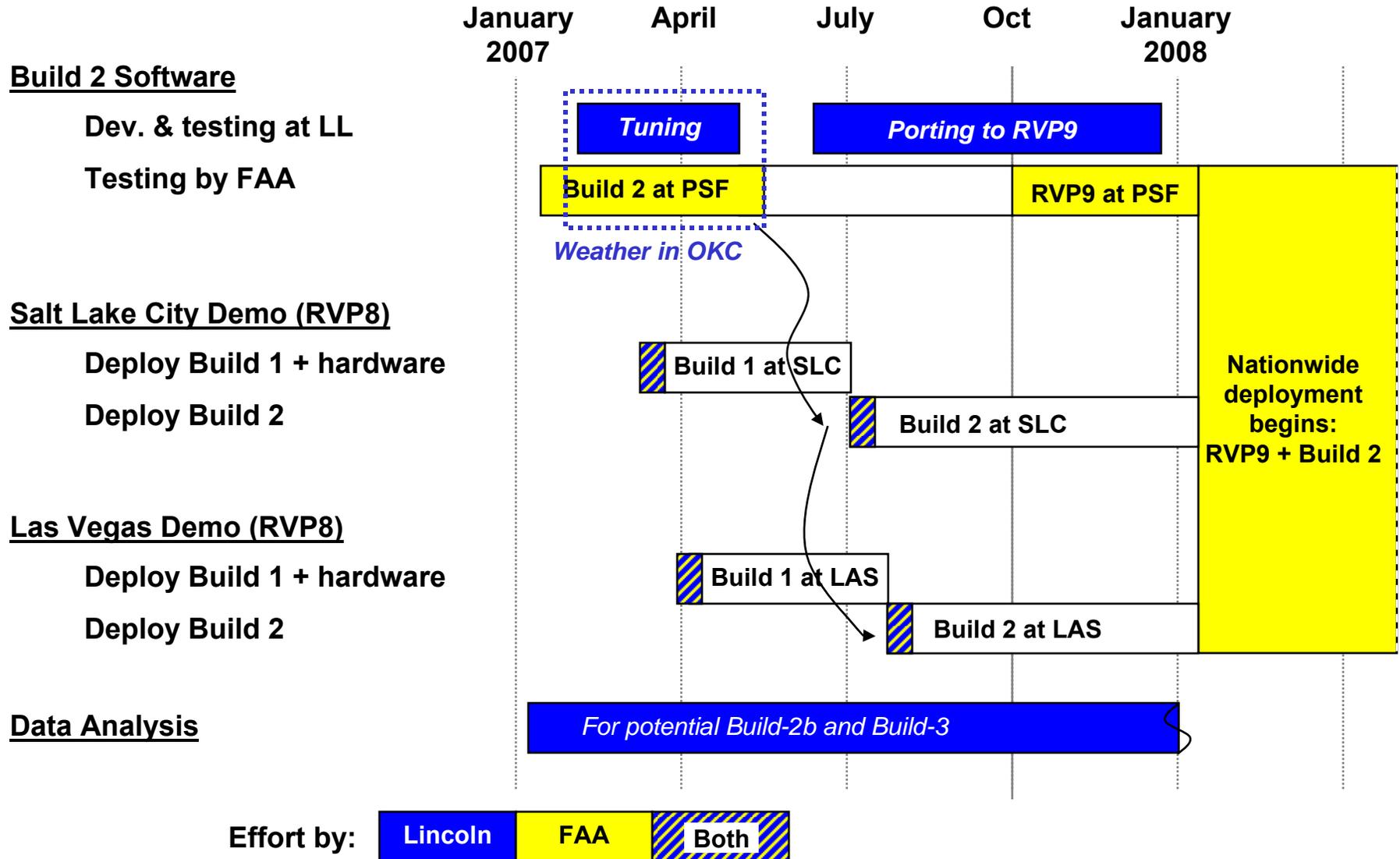
Technology Refresh

- **DSP computers were upgraded in Feb 2007 to a model similar to what will be deployed, leveraging latest technology**
- **Issue: PCI interconnect standard is being phased out by computer vendors, but is required by RVP8 receiver cards**
- **Two possible solutions**
 1. **RVP9 (due Jan 2008) will not use PCI;
Will require some integration by Lincoln**
 2. **External PCI expansion chassis can house RVP8 cards if RVP9 delivery is delayed**
- **External PCI chassis + RVP8 deployed to SLC in Spring 2007**





TDWR RDA Timeline





Summary

- **Milestones completed in FY06**
 - **Build 1 approved by FAA**
 - **Build 2 demonstrated successfully**
 - **Prototype ready for deployment to SLC**
- **FY07 milestones**
 - **Deploy prototypes to SLC and LAS**
 - **Meteorological evaluation of Build 2, complete testing**
 - **Delivery of remaining documentation to FAA**
- **AJW-144 indicates they are happy with the performance and design of the new RDA retrofit**



Comparison of Multi-PRI, Staggered PRI, and SZ Phase Code Processing on KOUN

John Cho
Igor Ivić (OU CIMMS/NSSL)

28 March 2007

FAA AWRP AWRT PDT

MIT Lincoln Laboratory



RV Ambiguity Mitigation Techniques

Ambiguity Mitigation

Range

Velocity

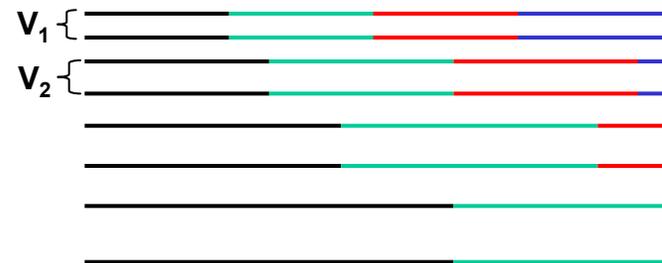
Phase Code



Staggered PRI



Multi-PRI



Spectral filtering

Shortest PRI allowed by Tx

Longest PRI allowed by Doppler coherence

Dual-PRI dealiasing

Selective range unfolding using surveillance cut

Multi-PRI dealiasing



Experimental Parameters

KOUN

- **EL = 0.5°**
- **Rotation rate = 19.4°/s**
- **Waveforms**
 - **Surveillance cut**
 - **Multi-PRI cut**
 - **PRIs = 0.77, 0.97, 1.3, and 2.1 ms**
 - **V range: ±35 m/s (w/dealiasing; can be greater)**
 - **10 pulses per PRI / 40 pulses per dwell**
 - **Staggered PRI cut**
 - **PRIs = 1.6 and 2.4 ms**
 - **V range: ±33 m/s (w/dealiasing)**
 - **26 pulses per dwell**
 - **SZ phase code cut**
 - **PRI = 0.77 ms**
 - **V range: ±34 m/s (no dealiasing)**
 - **64 pulses per dwell**

KTLX

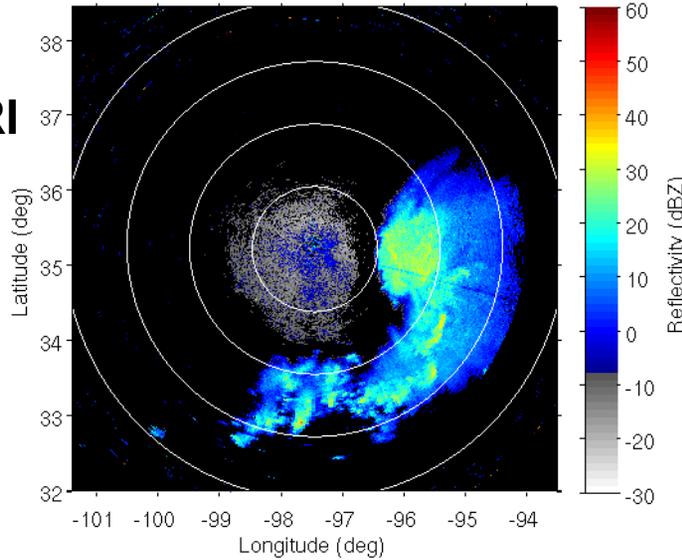
- **VCP 21**
- **EL = 0.5°**

Caveat: SZ and staggered-PRI processing algorithms implemented by Lincoln

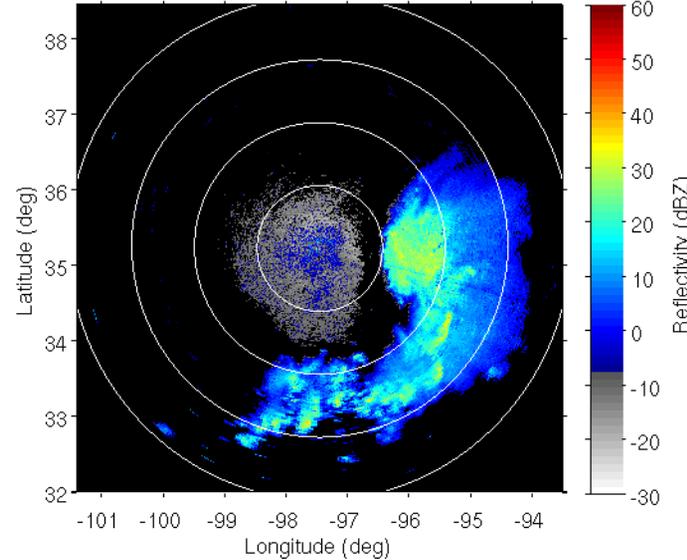


2006-11-6 03:56 Reflectivity

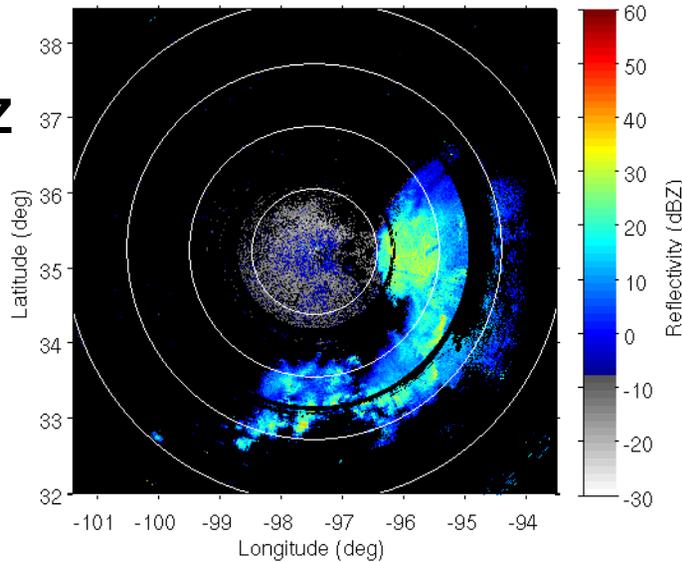
Multi-PRI



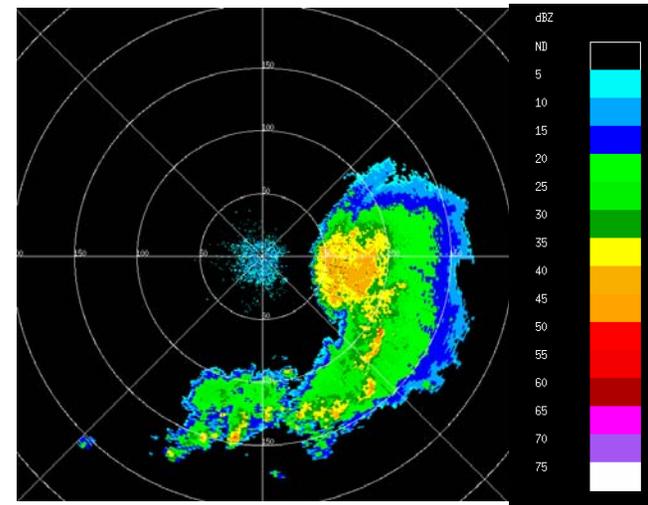
Staggered PRI



SZ



50-nmi range rings

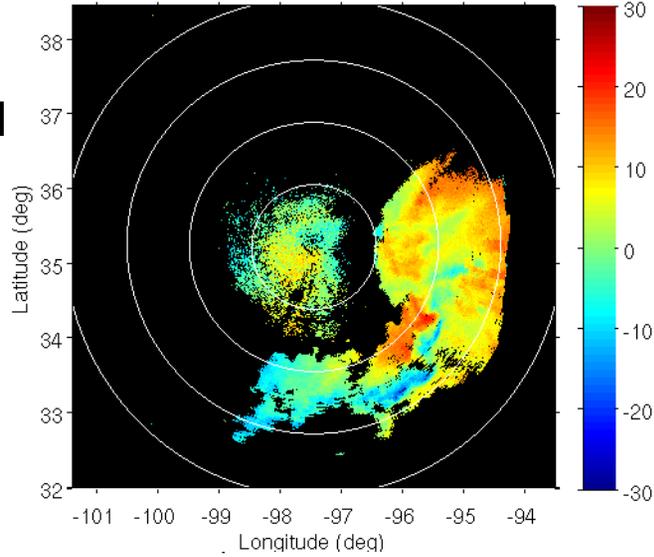


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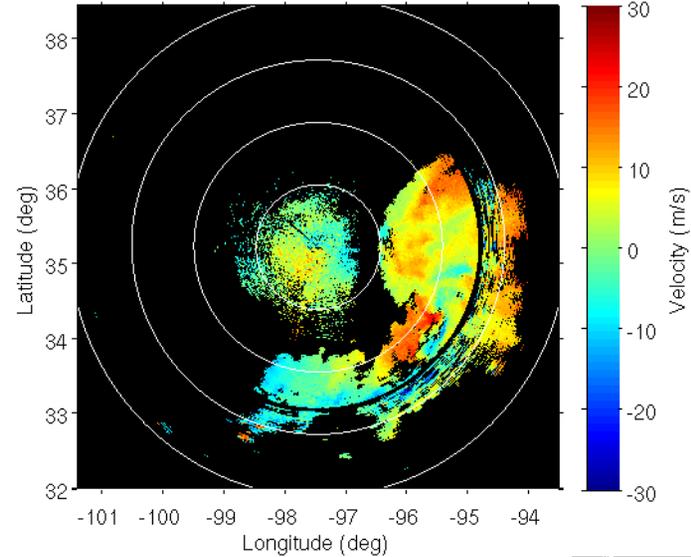


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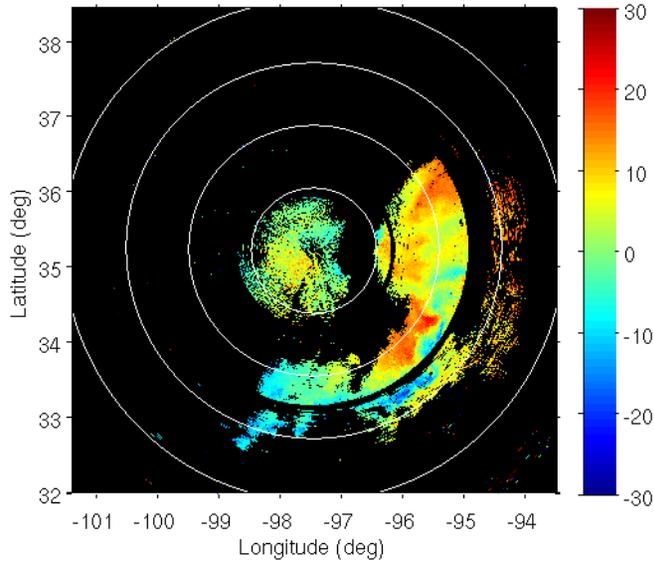
Multi-PRI



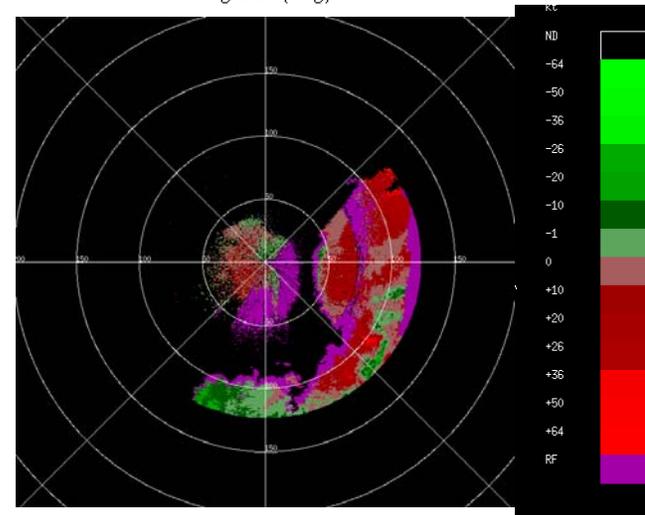
Staggered PRI



SZ



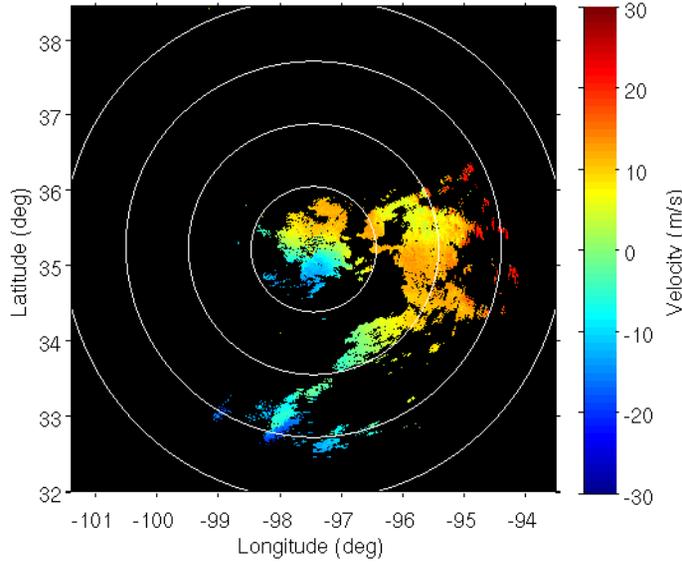
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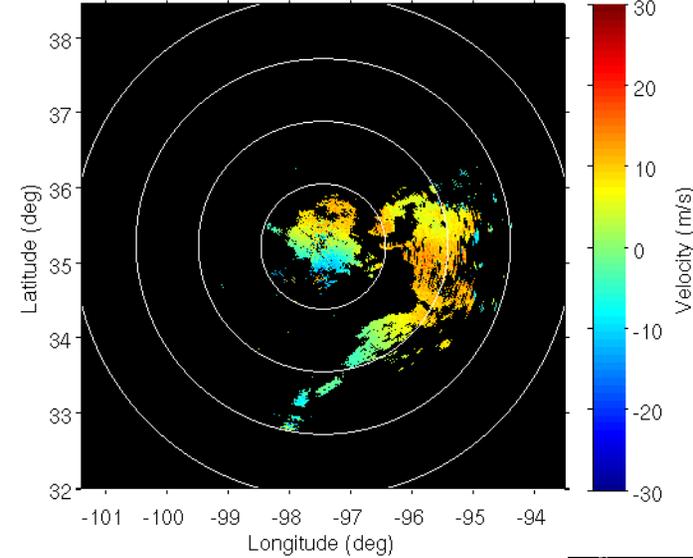


2006-10-25 14:39 Velocity

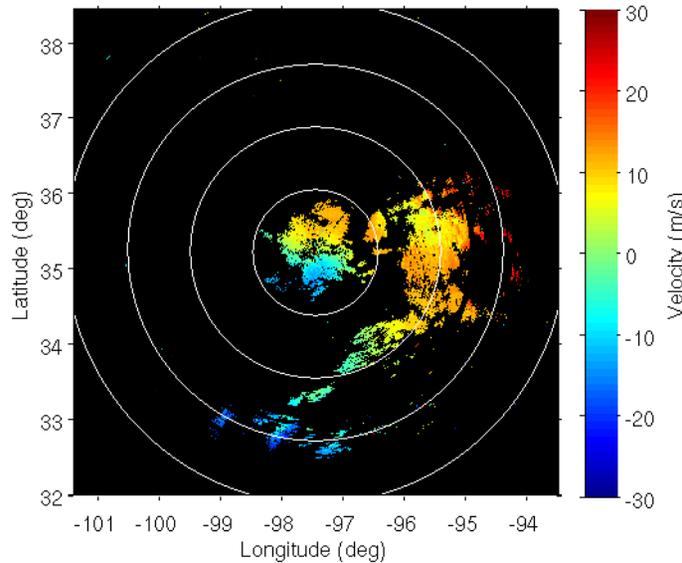
Multi-PRI



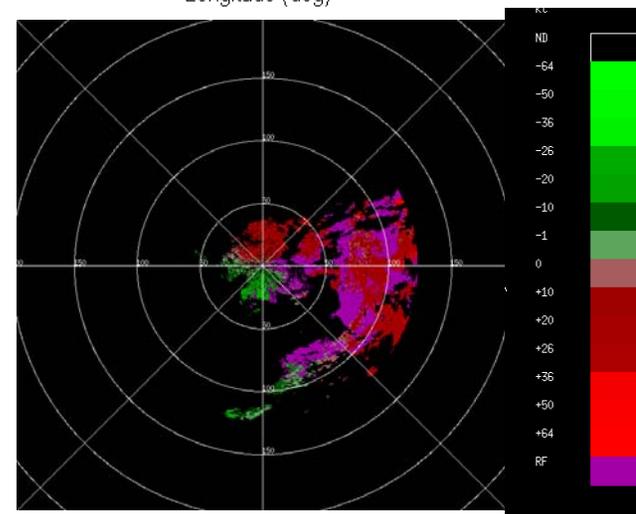
Staggered PRI



SZ



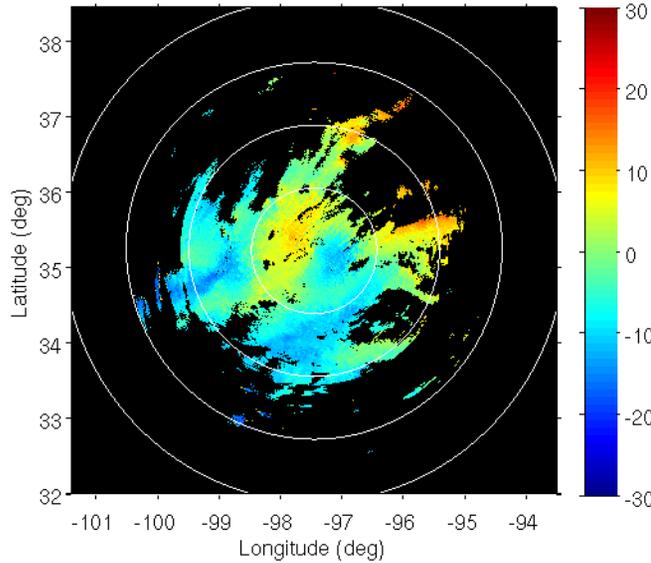
KTLX



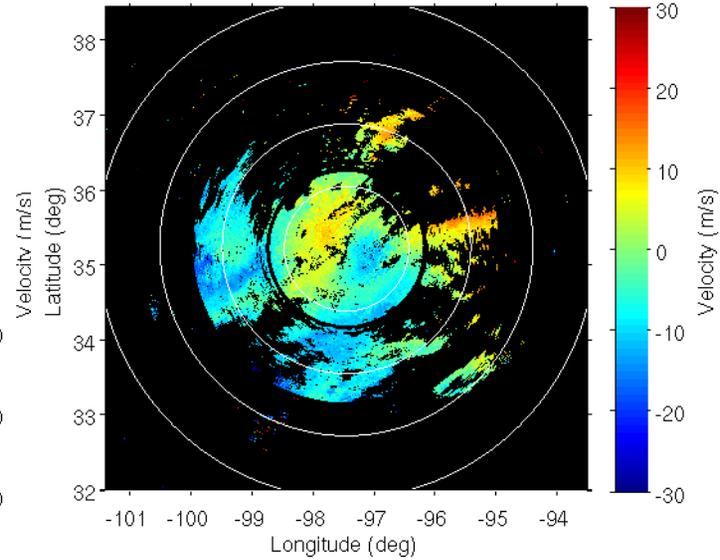


2007-10-16 22:32 Velocity

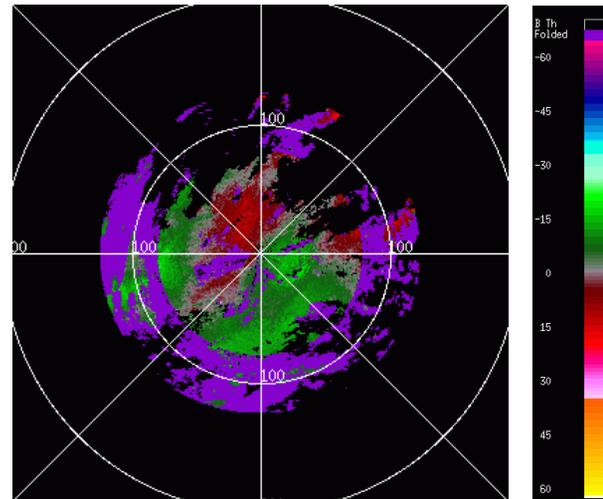
Multi-PRI



SZ



KTLX





Summary

	Phase Code	Staggered PRI	Multi-PRI
Range Coverage	Strongest 2 out of 4 trips at most	Up to r_a of longer PRI	Any range – depends on overlay pattern
Range Ring Gaps	Yes – at beginning range of trips > 1	Yes – just after r_a of shorter PRI	No
Spectral Processing	Yes	Yes – with restrictions	No
CPI Pulses	Large	Moderate	Small (per PRI)
Clutter Suppression	> 50 dB	> 50 dB	~ 50 dB
Velocity Dealiasing	No – high PRF	Yes	Yes